Designing Technology To Minimize Environmental

An aircraft fitted with Bete NF70 nozzles, which were shown in the lab to produce the optimum droplet size for oil dispersants. Field tests were conducted to simulate an actual dispersant treatment and verify the size and density of droplets deposited on the ground. **Right:** In-flight testing of water being released from the Bete nozzles.

When an oil spill occurs, it's the slick on the water that poses the main threat to the environment. Agricultural Research Service researchers are diving into the problem. They are helping fine-tune an important technology: aerial spray equipment designed to deal with the threat. Engineers at the ARS Areawide Pest Management Research Unit (AMPRU) in College Station, Texas, are working to ensure that compounds sprayed from airplanes will hit targeted oil slicks and break up oil spills.

Oil dispersants are a class of chemicals that break down oil in a waterway and disperse it into the water, reducing the environmental damage. Aircraft generally drop them on oil spills from altitudes of about 75 feet. "You want to have a gel that breaks up the film of oil on the water surface so that it dissipates into the water column, mitigating the effects of having it wash onshore and damage the shoreline," says W. Clint Hoffmann, lead scientist in AMPRU's aerial application technology section.

There are a number of oil dispersants and scientific reports that detail what happens when they interact with an oil slick. But thankfully there are very few major spills, so scientists don't get many chances to assess oil-spill technology. Hoffmann says the goal is to safeguard the environment by finding optimal technology for spraying three oil dispersants: Corexit 9500, Corexit 9527, and a new high-viscosity gel developed specifically to dilute oil spills.

Tunnel Vision

Engineers in the unit's aerial application technology section have spent decades studying the technology, methods, and effects of using crop dusters to spray crops such as corn and cotton with insecticides and other treatments. The unit's high-speed wind tunnel is one of a few wind tunnels nationwide capable of assessing how aerial sprays are "atomized," or broken into tiny droplets when released at high speeds.

The project began with researchers spraying the three dispersants separately into the wind tunnel, using different nozzles and measuring the size of the droplets produced. Droplet size plays a major role in determining where and how fast a compound will fall from an airplane, Hoffmann says. Generally, the larger the droplet, the more likely it will fall as desired—directly under the airplane.

"They want to be able to get the best results with these compounds and with their new high-viscosity gel. So the question is, 'What droplet size would be most effective at cleaning up oil spills?'" Hoffmann says.

To measure droplet sizes, the researchers placed a double-pulse laser downstream


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from the nozzles and used a high-speed camera to capture images of the droplets in flight as they went through the tunnel. Known as the "LaVision SprayMaster," the system allowed researchers to analyze up to 70,000 droplets as they passed through the laser beams. The camera's shutter and flash also enabled them to take between 8 and 16 images per second at a very high shutter speed, showing droplets in flight just after they were released from the nozzles. The nozzles released sprays at different pressure levels, ranging from 20 to 50 pounds per square inch (psi).

Simulating Flight

The three compounds were sent through the tunnel at about 140 miles per hour (mph), the speed normally traveled by planes used by cleanup crews during oil-spill recovery operations. Tarps on the ground captured the material as it came out of the tunnel so that it could be safely transported to an ARS biodegradation facility in College Station.

The droplet sizes observed in the wind tunnel tests were then applied to a spray-dispersion computer model to predict how well the compounds would hit targeted swaths during an oil-spill cleanup operation. The computer model, known as "AGDISP," is an industry standard and is used by federal regulatory agencies when they conduct environmental assessments of pesticides and other agricultural sprays.

The wind tunnel results show that the droplets produced by Corexit 9500 and Corexit 9527 were similar in size at the simulated 140-mph flight speed and that the droplets generally start to break up about 3 feet from a nozzle.

The results also show that a particular size nozzle, the Bete NF70 (Bete Fog Nozzle, Inc.), when set at 40 psi, would provide the best droplet sizes for accurate delivery. The computer modeling showed that 90 percent of either of the two compounds would land within the targeted swath, with 9.5 gallons of the spray hitting each targeted acre.

As for the gel, droplets formed from it were much larger than droplets from either of the other compounds, making it easier to ensure greater accuracy, even if dropped from higher altitudes, the researchers say. But the gel was so thick that the airborne delivery system will have to be redesigned to keep the gel from clogging the storage tank, pump, and spray booms on each aircraft.

The results were published in *Proceedings of the Arctic Marine Oil Spill Program Technical Seminar,* a book-length publication summarizing work reported at a June 2009 conference in Vancouver, British Columbia.

The work is continuing. Oil industry scientists plan on working with ARS researchers at the College Station facility to test their newly designed application systems and to confirm the computer modeling results with actual fight tests.—By **Dennis O'Brien,** ARS.

This research is part of Crop Production, an ARS national program (#305) described at www.nps.ars.usda.gov.

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Clint Hoffmann, agricultural engineer, positions a spray nozzle in a 140-mph airstream to simulate conditions for aerial application of an oil dispersant. The size of the dispersant droplets is measured with high-speed cameras and image-processing equipment.